REMARKS

The present remarks and amendments address all the issues raised in the Office Action dated June 8, 2006.

A. Objection to the Drawings

In the Office Action, the drawings were objected to because elements Z218 and 218' are in the specification but are not shown in the drawings. In response, applicants respectfully submit that elements Z218 and 218' are in fact shown in the drawings in their generic form, as elements Z2XX and 2XX', respectively.

As may be understood by viewing the specification and drawings in their entirety, it is intended that the generic portion "XX" of the designators "2XX," and the like, may be interpreted to correspond to any appropriate particular instance of a target source, and its corresponding particular dimension, or coordinate, or the like. For example, the generic designators 2XX, 2XX', and Z_{2XX} in FIGURE 4 may be interpreted to correspond to particular elements 218, 218' and coordinate dimension Z_{218}, which in turn correspond to the particular "218" elements shown in FIGURE 5, e.g., elements 218', $(x,y)_{218'}$, etc. The specification has been amended in the paragraph beginning at page 16, line 19, to clarify this, where the clarification underlined below is inserted:

> FIGURE 4 is a detailed schematic view of the first exemplary embodiment of a position sensor arrangement 200 shown in FIGURE 2, viewed along the direction of the minor axes of two elliptical structured light images according to this invention. Various relevant coordinate dimensions are shown. The various elements in FIGURE 4 appear according to their projections along the viewing direction, to the plane of the figure. The approximate positions of various elements normal to the plane of the figure are indicated in FIGURE 5. In FIGURE 4 and the following description, the designators "2XX," "5XX," etc., include a generic portion "XX" to emphasize the generality of the following description and equations. It is intended that the generic portion "XX" may be interpreted to correspond to any appropriate particular instance of a target source, and its corresponding particular dimension, or coordinate, or the like. For

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example, the generic designators 2XX, 2XX', and Z_{2XX} in FIGURE 4 may be interpreted to correspond to particular elements 218, 218' and coordinate dimension Z_{218}, which in turn correspond to the particular "218" elements shown in FIGURE 5, e.g., elements 218', $(x,y)_{218'}$, etc. Alternatively, the generic designators 2XX, 2XX', and Z_{2XX} in FIGURE 4 may be interpreted to correspond to particular elements 216, 216' and coordinate dimension Z_{216}, which in turn correspond to the particular "216" elements shown in FIGURE 5, e.g., elements 216', $(x,y)_{216'}$, etc. As shown in FIGURE 4, the target member 210 is rotated about an axis parallel to the direction of the minor axes of the elliptical structured light images. Reference numbers in common with FIGURE 2 denote substantially similar elements. Thus, such elements will be understood from the description of FIGURE 2, and only certain additional coordinate relationships and elements not shown in FIGURE 2, are described here.

It is respectfully submitted that this amendment does not add any new matter to the specification, but merely clarifies what is described in or evident from the specification as filed as a whole. See, in the original specification as filed, for example:

Page 18, Line 17:

The image detector image 500 includes four elliptical structured light images 515, 516, 517 and 518, arranged to correspond approximately to the structured light target member and position sensor arrangement 200 shown in FIGURE 4, along with various relevant coordinate dimensions. Each structured light image 5XX corresponds to the similarly numbered target source vertices 2XX'. Assuming that, based on the pixel data of the image 500, a respective best-fit ellipse has been analytically determined for each respective elliptical structured light image 5XX, each structured light image 5XX is completely characterized in terms of the image detector coordinate system. For example, the center of each ellipse $(p,q)_{5XX}$, the minor axis dimension B_{5XX}, the major axis dimension A_{5XX}, and the angle θ between the direction of the major axes and the x-axis of the image detector coordinates is also known. Accordingly, the coordinates of all points on each ellipse can be determined according to known methods, as needed. The image detector coordinates $(x,y)_{2XX'}$ of each target source vertex 2XX' are to be determined eventually, as outlined further below.

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Page 20, Line 17:

> Furthermore, as may be seen in FIGURE 4, using the known cone angle α, the known dimension Z_{215} and the determined relative rotation angle ϕ, the dimension El_{215} between the point P_{A1} and the vertex 215', along the major axis of the ellipse 515 in the image 500, can be determined from the following general expression (with 2XX = 215):
>
> $$El_{2XX} = Z_{2XX} * \tan(\alpha+\phi) \qquad \text{(Eq. 6)}$$

Accordingly, applicants respectfully request entry of the above amendment to the specification and withdrawal of the previous objections to the drawings.

B. Objection to the Specification

In the Office Action, the specification was objected to because elements Z1 and Z2 need explanation on page 10, and on page 17 elements Z_{218} and 218' are not reflected in the drawings.

Regarding element Z_{218}, based on applicants' foregoing explanation under Objection to the Drawings, it will be understood that element Z_{218} is reflected in the FIGURE 4 by the generic indicator Z_{2XX}. This is reinforced by the example at page 20, line 13:

> With reference to FIGURE 4, we can now determine the relative rotation angle ϕ as follows. The dimension Δz shown in FIGURE 4 is $\Delta z = Z_{215}-Z_{218}$, therefore the relative rotation angle ϕ may be determined as:
>
> $$\phi = \sin^{-1}\left(\frac{\Delta z}{S_{major}}\right) = \sin^{-1}\left(\frac{Z_{215}-Z_{218}}{S_{major}}\right) \qquad \text{(Eq. 5)}$$

Applicants respectfully submit that the amendment to the specification explained under Objection to the Drawings addresses the issue related to element Z_{218}.

Regarding element 281', it is shown in the upper right quadrant of FIGURE 5.

Regarding Z1 and Z2, these are merely "specific" values for Z, defined by equation, and used within the context on page 10 for purposes of illustration and explanation. Page 10 states:

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> *For example*, for such a configuration, *when* $Z=Z_1$ the operable pixels forming the operable structured light image will be a set of pixels forming a circle of radius $R_1=Z_1*\tan\alpha$ on the imaging array. *If* the separation between the focal point 115' and the imaging array is then increased to $Z=Z_2$, the operable pixels forming the operable structured light image will be a new set of pixels, forming a larger circle of radius $R_2=Z_2*\tan\alpha$. [*Emphasis added.*]

It is respectfully submitted that the terms in this self-contained illustrative example are readily understood based on the entirety of the description of FIGURE 1, and adding corresponding elements to FIGURE 1 would only complicate its interpretation.

C. Rejection of Claim 1 under 35 U.S.C. 112

In the Office Action, Claim 1 was rejected under 35 U.S.C. 112 for lack of antecedent basis for "the array detector". Claim 1 has been amended to use the term "imaging array detector" consistently throughout the claim.

D. Rejection of Claim 1 under 35 U.S.C. 102(e)

In the Office Action, Claim 1 was rejected under 35 U.S.C. 102(e) as being anticipated by U.S. Publication No. 2004/0032596 A1 to Lange. Applicants respectfully traverse the rejection and submit the following.

Applicants respectfully point out that Claim 1 has not been interpreted in light of the specification. In particular, in the sense described in the present application and illustrated in the figures, Lange does not include a structured light generating target member. Rather, the configuration of Lange teaches directing a laser source toward a target optical element that reflects first and second reflected beams.

Firstly, the target optical element (37) of Lange, allegedly corresponding to "the structured light generating member" reflects light, but does not *generate* light as recited in Claim 1. In contrast, in the present specification at page 8, line 21, it is stated:

> In various exemplary embodiments of a position sensor according to this invention, *light propagates through a plurality of axicon lenses* located on a target member, and each lens forms a structured light cone. As will be described in greater detail below, each respective structured light cone forms a ring-shaped image on a two-dimensional imaging array of the position sensor, and the image is indicative of the 3-dimensional position of the respective axicon lens that *generates* the structured light cone. [*Emphasis added.*]

Secondly, the target optical element (37) of Lange, allegedly corresponding to "the structured light generating member," reflects light, but does not generate *structured* light as recited in Claim 1. Structured light is generally understood in the art to be a projected pattern of light having a known structure in a known relationship to the structured light source. In contrast, in the system of Lange, only a portion of the element 40 is illuminated at any one time, and the first and second reflected beams from the operative portion of the element 40 will therefore wander around on the detector 42 in dependence on the position of second object 31 and the element 40. The second object 31 does not project a pattern of light having a known structure in a known relationship to the element 40, and therefore does not constitute a structured light generating member, as that term would ordinarily be understood in the art and as that term is used in the specification.

However, in order to expedite examination, applicants have amended Claim 1 to add additional explanation in the form of structural limitations associated with a structured light generating member, and in particular, as disclosed by applicants in the specification.

Applicants' amended Claim 1 now recites "...at least three respective target sources that output at least three respective structured light patterns..." Support for this amendment is found, for example, at page 5, line 7, "Thus, a set of (x,y,z) coordinates can be determined for any such target source, and given the (x,y,z) coordinates of three such target sources, a 6-degree-of-freedom relative position can be determined between a target member and a position measuring device according to this invention", and at page 24, line 19, "As previously indicated, in various

exemplary embodiments, at least three structured light images, such as the ellipses 515-518, fall within the field of view of the image detector 230 at all times."

Applicants' Claim 1 has also been amended to delete the more general limitation "...the image on the array detector is usable to determine at least one measurement value that corresponds to at least one degree of freedom of the relative position between the imaging detector and the target member." This general limitation is replaced with the more specific limitations:

> each of the at least three respective target sources gives rise to a corresponding respective image feature in the image on the imaging array detector; and
>
> a size characteristic of each of the at least three corresponding respective image features in the image is usable to determine a z-coordinate value for a respective reference point that is fixed relative to the corresponding respective target source, the z-coordinate value corresponding to a translational degree of freedom along a z-axis that extends along a direction of varying separation between the imaging array detector and the target member the output structured light patterns being in a fixed relationship relative to the target member.

Support for these specific limitations is provided by FIGURES 4 and 5 and their related description, for example. Support for these amendments is also found, for example, at page 4, line 26:

> The size of the ring-shaped structured light image corresponding to a target source can thus be used to determine an absolute z-axis coordinate for a corresponding target source or other reference feature relative to the detection plane, or reference plane, of the imaging array....Thus, a set of (x,y,z) coordinates can be determined for any such target source, and given the (x,y,z) coordinates of three such target sources, a 6-degree-of-freedom relative position can be determined between a target member and a position measuring device according to this invention.

Another supporting example is at page 24, line 19, "As previously indicated, in various exemplary embodiments, at least three structured light images, such as the ellipses 515-518, fall within the field of view of the image detector 230 at all times."

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The teachings of Lange fail to include a number of the limitations now explicitly recited in amended Claim 1. Lange does not include or suggest the use of "at least three respective target sources," as the term "target source" is interpreted by the Examiner in Lange. In fact, according to analysis and measurement methods described by Lange, Lange only uses first and second reflected beams, and has no need for more than one target source. Furthermore, Lange provides no means for illuminating or imaging more than one target source, since Lange requires a laser beam that only partially fills just one element 37.

Furthermore, Lange does not include or suggest "the output structured light patterns being in a fixed relationship relative to the target member," as the term "structured light pattern" is interpreted by the Examiner in Lange. As previously noted, only a portion of Lange's element 40 is illuminated at any one time, and the first and second reflected beams from the operative portion of the element 40 will therefore wander around on the detector 42 in dependence on the position of second object 31 and the element 40. Therefore, the second object 31 of Lange does not project a structured light pattern that is in a fixed relationship relative to a target member.

Based on the above explanation, applicants respectfully submit that Claim 1 is in condition for allowance. The subject matter recited in Claim 1 has only been made more explicit and/or specific. The scope of Claim 1 has not been enlarged or changed.

New Claims 2-17 all depend from Claim 1 and therefore are further believed to be allowable for at least the same reasons why Claim 1 is allowable, as discussed above. Further, Claims 2-17, as amended, include additional limitations that provide further distinctions with respect to Lange.

Regarding Claim 2 and Claim 3 (which depends from Claim 2), as previously noted, Lange provides no means for illuminating or imaging more than one target source, and therefore

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cannot provide or use "the locations of a plurality of the corresponding respective image features in the image," as recited in Claim 2.

Regarding Claims 4 and 5, Lange suggests only "centroid" finding. Because Lange provides only one "filled" spot (or blob) in an image, Lange does not recognize or suggest the utility of fitting an ellipse to an elliptical pattern, or utilizing its major and minor axes and center in the manner recited in Claim 4. Because Lange provides only a "filled" spot in an image, the existence or analysis of a radial intensity profile associated with an ellipse, as recited in Claim 5, is not described or suggested by Lange. Claim 4 is supported in FIGURE 12 and its description, for example. Claim 5 is supported in FIGURE 9 and its description, for example (see radial intensity profile elements 930A-930D).

Lange does not teach or suggest any of the limitations found in Claims 6-12.

Regarding Claim 6, it is supported throughout the specification and, for example, in FIGURE 3A, and at page 3, line 15, "In various exemplary embodiments, the target sources are arranged in a two-dimensional periodic array on the target member."

Regarding Claims 7 and 8, they are supported in FIGURE 20 and the related description, and more generally throughout the specification. For example, at page 4, line 16:

> Thus, in accordance with a further aspect of the invention, in various exemplary embodiments, the structured light image on the imaging detector (also referred to as an array detector) comprises a continuous, or segmented, circular or elliptical pattern formed where the hypothetical cone intersects with the plane of the optical detector elements of the imaging array. In various embodiments, the segments of the circular or elliptical pattern are essentially spots... In accordance with a further aspect of the invention, the continuous or segmented circular or elliptical (ring-shaped) image corresponding to a target source has a size that varies with the separation along a direction parallel to an axis of separation between the imaging array and the target member.

Regarding Claim 9, it is supported by EQUATION 1, and at page 16, line 12:

> Thus, the dimension of the minor axis of an elliptical structured light image closely corresponds to the dimensions d_{215} and d_{216} shown in FIGURE 2 (within approximately 1% when the rotation about the minor axis is 25 degrees), and the Z coordinate of a respective target source vertex corresponding to a respective elliptical structured light image can be accurately estimated by EQUATION 1, when the value used for *d* is the dimension of the minor axis of the ellipse.

Regarding Claim 10, it is supported throughout the specification and, for example, in FIGURES 4, 13, 14, 18, and 19, and related description, as well as at page 4, line 5, "In accordance with another aspect of the invention, a target source receives collimated light from a light source and outputs the structured light pattern."

Regarding Claim 11, it is supported throughout the specification and for example, in FIGURES 1, 2, 4, 13, 14, 16, and 17, and related description, for example, at page 43, line 9, "The target source configuration 1600 includes a ring-shaped target source 1615 that produces a structured light pattern 1642, that may be described as a pair of structured light cones, one inverted and one not, with a common vertex at the plane 1622", and at page 4, line 16, "Thus, in accordance with a further aspect of the invention, in various exemplary embodiments, the structured light image on the imaging detector (also referred to as an array detector) comprises a continuous, or segmented, circular or elliptical pattern formed where the hypothetical cone intersects with the plane of the optical detector elements of the imaging array."

Regarding Claim 12, it is supported throughout the specification and, for example, in FIGURES 13, 14, 16, 17, and 20, and related description, for example, at page 43, line 9, "The target source configuration 1600 includes a ring-shaped target source 1615 that produces a structured light pattern 1642", and at page 3, line 26, "In various exemplary embodiments, a target source comprises a refractive axicon point-like lens (an axicon point), a refractive axicon ring, a refractive faceted pyramidal-type point-like lens, a refractive polyhedral-like arrangement

of prismatic 'lines,' an arrangement of one or more refractive prismatic 'lines,' or any combination thereof. In various other exemplary embodiments' respective diffractive optical elements, that deflects light rays approximately like the corresponding respective refractive optical elements listed above, may be used instead of refractive optical elements."

Method Claims 13-17 correspond closely to Claims 1-4 and are therefore allowable for similar reasons.

Based on the foregoing, applicants respectfully request allowance of the present application including Claims 1-17. If the Examiner should have further issues to resolve, he is invited to telephone applicants' undersigned attorney at the number set forth below.

Respectfully submitted,

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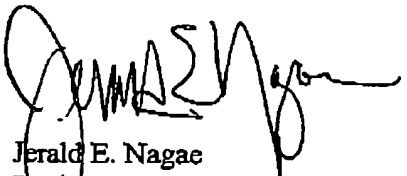

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